

ATTAC Project No. VELA T/6708
ARPA Order No. 621
ARPA Program Code No. 6F10

Distribution of this document
is unlimited

EXPLOSION PROGRAM
KURILE ISLANDS EXPERIMENT

Special Report No. 2
OCEAN-BOTTOM SEISMOGRAPHIC EXPERIMENTS

Prepared by
Ralph Guidroz, Fred Howard and John Frederic

Ralph R. Guidroz, Program Manager
Telephone: 1-214-357-5411, Ext. 447

TEXAS INSTRUMENTS INCORPORATED

Science Services Division

P.O. Box 5621
Dallas, Texas 75222

28 April 1967

ACKNOWLEDGMENT

This research was supported by the
ADVANCED RESEARCH PROJECTS AGENCY,
Nuclear Test Detection Office,
under Project VELA UNIFORM,
and accomplished under the technical direction of the
AIR FORCE TECHNICAL APPLICATIONS CENTER,
Contract No. F 33657-67-C-0105

Effective Date of Contract: 28 July 1966

Contract Expiration Date: 27 April 1967

Amount of Contract: \$892,217

D D C
RECEIVED
NOV 14 1967
RECEIVED
C

AFTAC Project No. VELA T/6708
ARPA Order No. 624
ARPA Program Code No. 6F10

Distribution of this document
is unlimited

EXPLOSION PROGRAM
KURILE ISLANDS EXPERIMENT
Special Report No. 2
OCEAN-BOTTOM SEISMOGRAPHIC EXPERIMENTS

Prepared by
Ralph Guidroz, Fred Howard and John Frederic

Ralph R. Guidroz, Program Manager
Telephone: 1-214-357-5411, Ext. 447

TEXAS INSTRUMENTS INCORPORATED
Science Services Division
P.O. Box 5621
Dallas, Texas 75222

28 April 1967

ACKNOWLEDGMENT

This research was supported by the
ADVANCED RESEARCH PROJECTS AGENCY,
Nuclear Test Detection Office,
under Project VELA UNIFORM,
and accomplished under the technical direction of the
AIR FORCE TECHNICAL APPLICATIONS CENTER,
Contract No. F 33657-67-C-0105

Effective Date of Contract: 28 July 1966
Contract Expiration Date: 27 April 1967
Amount of Contract: \$892,217



TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION	I-1/2
II	METHOD	II-1
III	CRITIQUE	III-1/2

LIST OF APPENDIXES

Appendix	Title
A	RELIABILITY DATA
B	MATERIAL INVENTORY

TABLE

Table	Title	Page
1	Charge Detonation Data	II-8

LIST OF ILLUSTRATIONS

Figure	Description	Page
1	M/V Campeche Seal	II-1
2	A-Frame Assembly	II-2
3	1-Ton Charge	II-4
4	5.2-Ton Charge	II-5
5	Event and System Chart	II-9/10
6	Visicorder Recording, 5.2-Ton Charge Detonation	II-11/12



SECTION I

INTRODUCTION

During October, November and December 1966, an Ocean-Bottom Seismograph experiment was conducted near the Kurile Islands to evaluate the seismicity of the area and to confirm the operational worthiness of the instrument. In addition to the recording of earthquakes, calibration charges were fired to provide additional data for evaluation of travel times for this region. The objective of this report is to detail the procedures developed for the explosion program and to give the reliability of the calibration data.

The explosive used was 120,000 lb of high-energy composition B packed in 50-lb cubical cans (9-1/2 in. side), which was shot in ten 5.2-ton, six 1-ton and one 1.5-ton packages. These charges were exploded in a network designed to provide optimum recording on the ocean-bottom instrumentation and minimum damage to marine life. The shots were restricted to the following conditions: daylight hours, 2 mi or more from any approaching vessel, a minimum of 1300 fm of water depth, and/or more than 100 km from land.

BLANK PAGE



SECTION II METHOD

Ship Rigging — Figure 1 shows the 165-ft M/V Campeche Seal and the special rigging necessary to accomplish the calibration program.

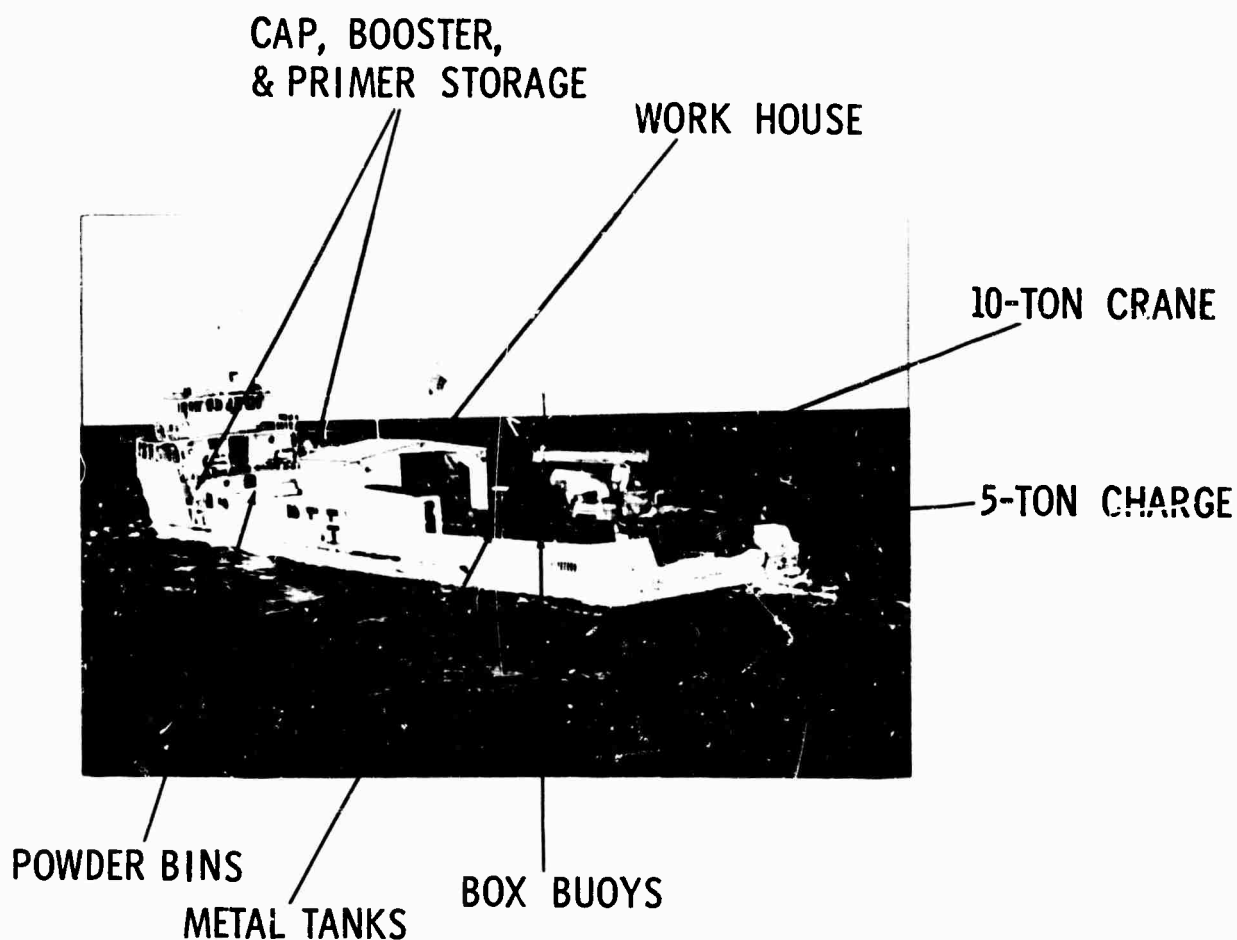


Figure 1. M/V Campeche Seal



For powder storage, two 210-x-135-x-38-in. wood-lined powder bins were constructed, each providing a 61,600-lb or 1232-can capacity. Caps, boosters and primers were stored in two wood-lined metal boxes behind the ship's superstructure. Roller conveyers were used to move the powder 75 to 100 ft to the loading area.

Each charge was launched from the stern of the M/V Campeche Seal by lifting an A-frame with a 10-ton hydraulic crane (Figure 2). The charges were placed on two 2-x-6-x-84-in. wooden skids. When the A-frame was inclined, the charge slid into the water.

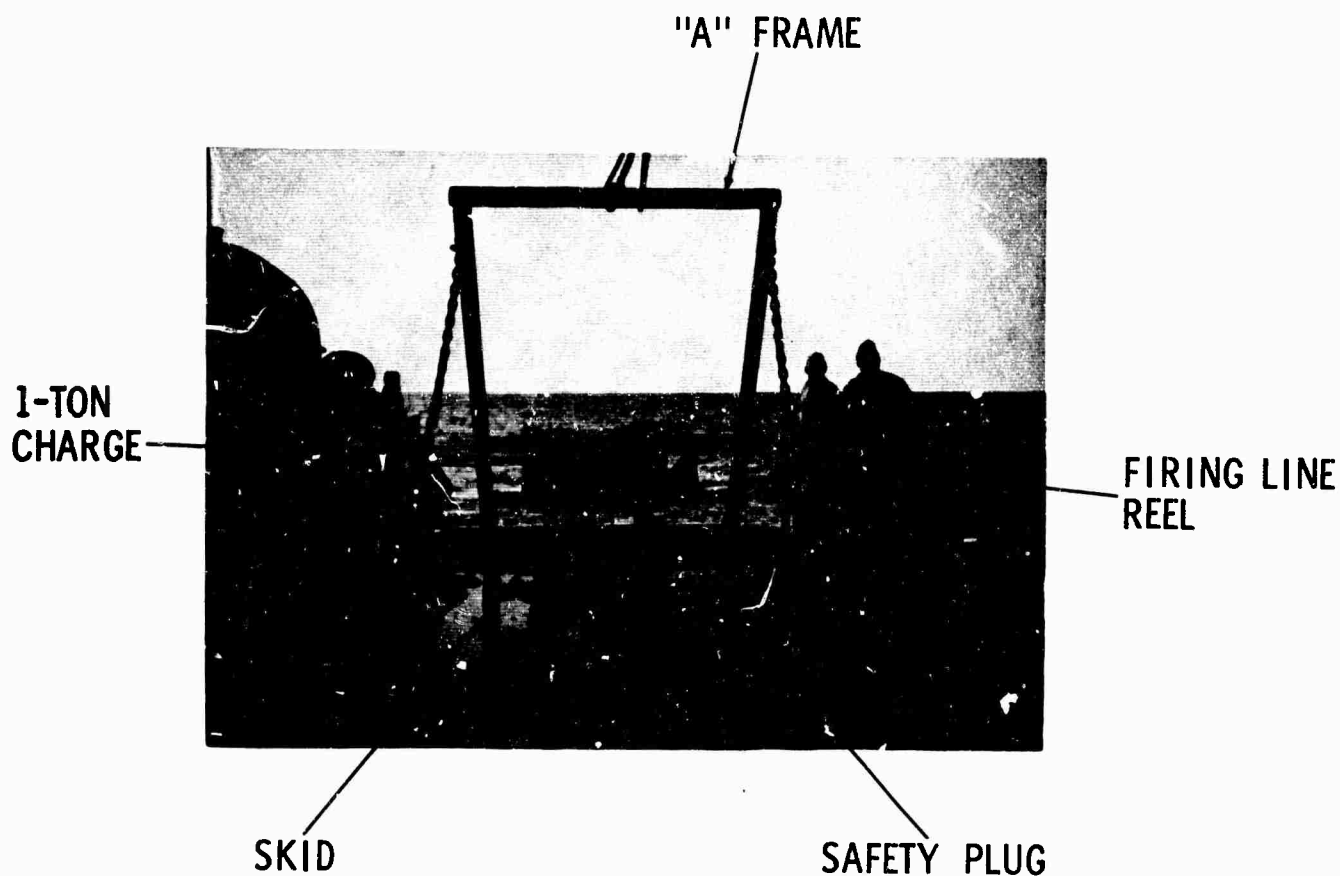


Figure 2. A-Frame Assembly



Material — Explosives used were government-furnished property stored at the U. S. Naval Ordnance Depot in Bangor, Washington, and delivered to the Naval Ordnance Depot in Seal Beach, California. Primers, boosters and caps were obtained from the Washington state supply center of E. I. duPont de Nemours and Co., Inc.

The material list for the calibration shots included:

- Firing equipment — firing line, blaster, blasting-cap safety plug, marine geophone, WWV receiver, 6-channel galvoamplifier, and Visicorder
- Packaging material — metal banding, nylon line, manila rope, jet engine tanks, and lumber
- Flotation material — nylon line, polyurethane inflatable buoys, styrofoam blocks, and wooden box buoys filled with styrofoam

The appendix presents a complete inventory containing specific material requirements.

1-Ton Charge — Each 1-ton charge was constructed of two layers of 20 cans banded to a 38-x-48-in. wooden pallet with 115 ft of 1-in. banding (Figure 3). To allow space for primers, two 5-x-9-in. spacers were placed in the top and side of each charge. Two primers, two boosters and two caps were used to fire each of these charges.

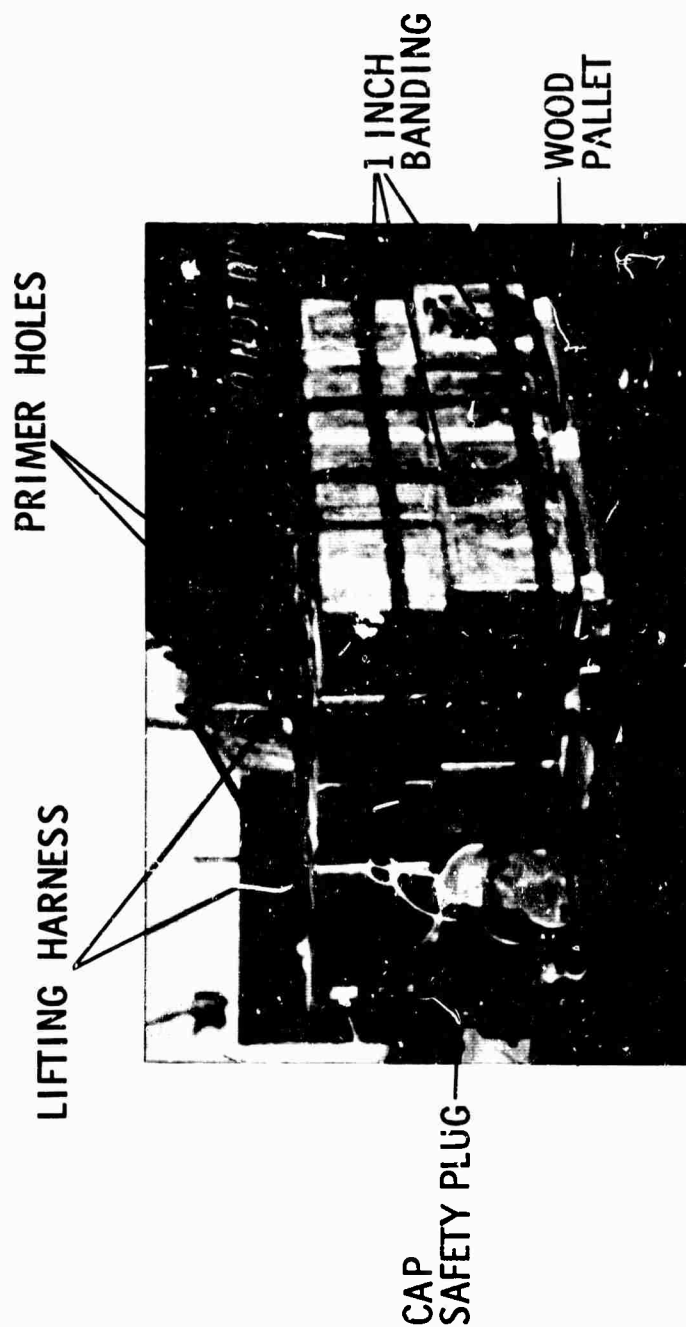


Figure 3. 1-Ton Charge



5.2-Ton Charge — The 5.2-ton charge consisted of 209 cans of explosive packaged in a 4-x-5-x-9.5-ft metal tank (Figure 4). Four primers, four boosters, and four caps were placed at intervals in the middle two rows of cans for charge detonation (with the exception of E7A and E14 where three of each component were used in a similar method). For E12, E13, E7A, and E14, two plywood sheets were used to cover the charge, reducing to half the quantity of banding normally used. These charges were constructed in the launch position.

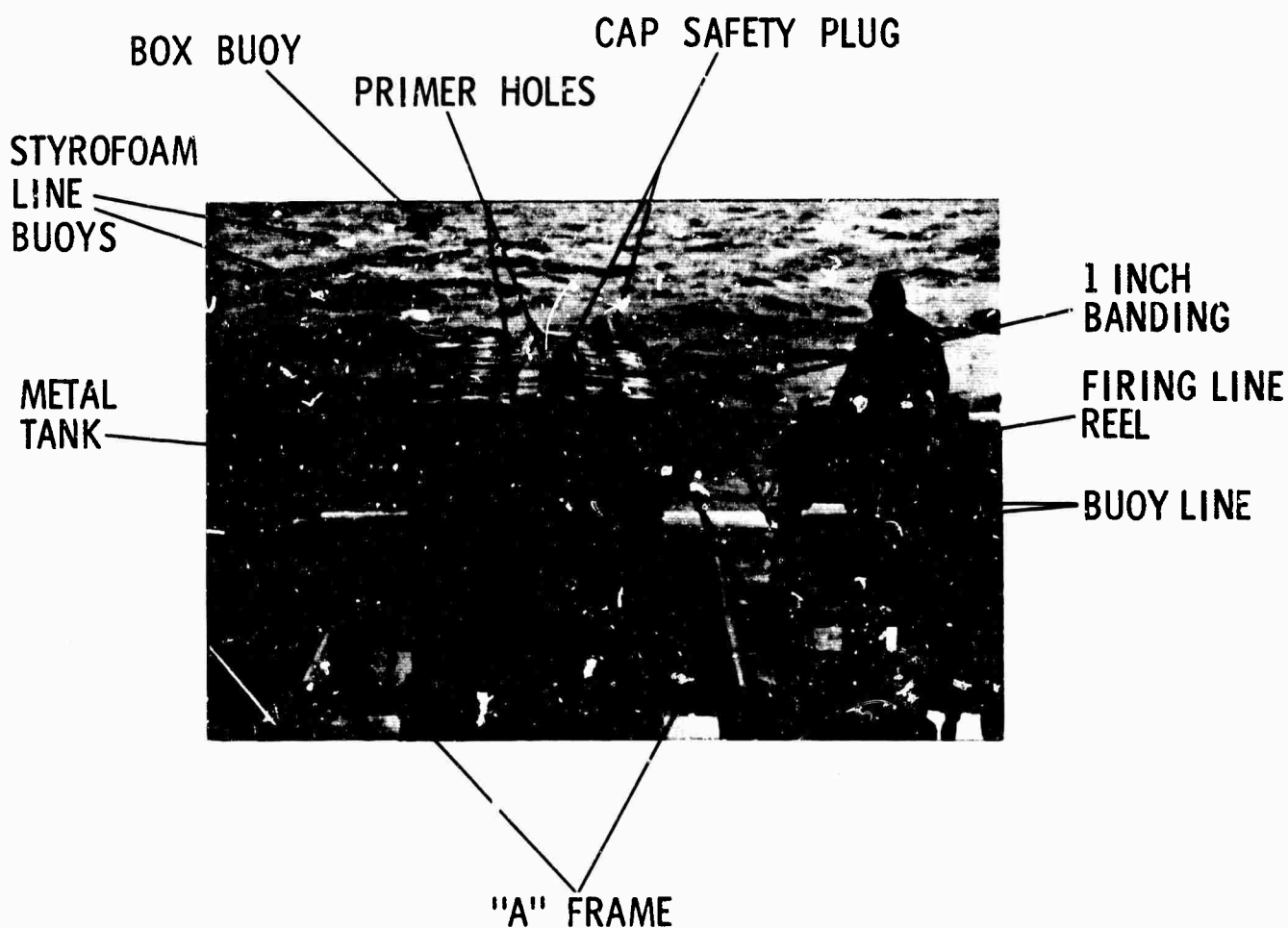


Figure 4. 5.2-Ton Charge



Launching Technique -- A lifting harness made of 3/4-in. dia nylon line was looped around each 1-ton charge. This line was positioned on opposite sides of the charge by 2-x-4-x-36-in. wooden spacers. Then, a 10-ton crane was used to move each charge from the workhouse to the stern of the ship. As stated earlier, each charge was placed on two 2-x-6-x-84 in. wooden skids which were on an inclinable A-frame.

After each 1-ton charge was positioned, a 300-ft, 1-in.-dia nylon buoy line was attached to the lifting harness on the outboard side of the charge.

For flotation, five 30-x-36-in. oval polyurethane surface buoys and three 10-x-20-x-36-in. styrofoam blocks were spaced at 75-ft intervals along the buoy line. Wound on a firing-line reel adjacent to the charge was 1 mi of Type DSA-500-31246 firing line; this lightweight firing line was used because of its comparative ease of handling.

During early shots with the 5.2-ton charge, the buoy line was wrapped around the rim of the charge, resulting in a loss of approximately 30 ft of line per charge; therefore, a separate harness line was used during the latter part of the program.

In addition to the flotation material used for 1-ton charges, three styrofoam blocks used for the buoy line (600 ft of 1 1/2-in. nylon line) and a box buoy filled with styrofoam were required for the 5-ton charge. Type DSA-500-31246 firing line was also used for this charge.

After either 1-ton or 5.2-ton charges were brought into launch position, they were loaded with primers and boosters and the caps placed in safety plugs. The cap leads were connected to the firing line, and both leads and the firing line were tied to the buoy lines. During this time and continuing through the detonation period, radio and radar transmitting equipment was turned off as a safety precaution to prevent premature detonation of the firing caps.



Buoys and line were thrown overboard, with the ship proceeding at a slow speed. Some firing line was released and then the caps placed in the boosters. As the buoys began to pull against the charge, the crane lifted the A-frame, launching the charge.

Detonation — The calibration charges were distributed in a network (Figure 5) which provided optimum recording within the stated restrictions. Charges were detonated from 0.5 to 0.75 mi from the ship and were 300 to 680 ft below the surface of the water. Table 1 presents the operational and observational data for the complete explosion series.

It took approximately 45 sec for the 1-ton charge to reach the 300-ft extent of the buoy line and 75 sec for the 5.2-ton charge to reach 600 ft. For the 1-ton charge, the distance between ship and charge was about 2600 ft; this distance was increased to about 4500 ft for the 5.2-ton charge. When the proper distance was reached, the ship was stopped and the following steps initiated:

- Cap check (firing-line resistance check made from blaster through blasting caps, confirming firing line impedance)
- Firing line connected to blaster
- Marine geophone dropped to depth of 20 ft
- Blaster charged with 2000 v, and time calibration verified from WWV receiver
- Paper recorder started 5 sec before detonation in order to record time of detonation, time signal and marine geophone response
- Charge detonated
- Firing line, buoy and buoy line retrieved

Figure 6 shows the Visicorder recording for a 5.2-ton charge. (Time signals are discussed in Appendix A.)



Table 1
CHARGE DETONATION DATA

Pos. No.	Date (1966)	Operational		Observational	
		Location		Pressure Wave Arrival (GMT)	Visicorder Record Quality
		Lat. N	Long. E	First Bottom Reflection (GMT)	
E11	5 Nov	43°06'	148°04'	23:24:03.4	Fair
E9	6 Nov	43°35'	148°17'	03:33:06.2	Poor
E10	7 Nov	43°01'	149°12'	04:03:02.4	Very Good
E8	8 Nov	44°00'	149°20'	01:50:03.4	Good
E7	8 Nov	44°23'	148°58'	06:53:02.8	Poor
E5	9 Nov	44°31'	151°12'	00:09:04.6	Poor
E6	9 Nov	43°31'	151°57'	No Geophone	Fair
E4	9 Nov	45°35'	152°04'	23:23:03.7	Good
E2	10 Nov	46°20'	153°00'	No Geophone	Poor
E3	12 Nov	46°07'	153°12'	No Geophone	Poor
E2A	12 Nov	46°21'	152°58'	23:31:03.6	Poor
E1	13 Nov	46°59'	153°54'	05:48:03.6	Good
E12	2 Dec	43°02'	150°25'	22:30:03.4	Poor
E13	3 Dec	43°40'	149°42'	05:21:03.4	Good
E7A	3 Dec	44°25'	148°58'	22:49:03.6	Very Good
E14	4 Dec	44°35'	150°51'	22:24:03.6	Good
E5A	5 Dec	44°31'	151°22'	03:22:03.6	Fair

* Depth values are determined from buoy line measurements, using a 20-ft track as a scale. A stretch factor characteristic of the nylon buoy line (15 ft for 1-ton charges with 300 ft of buoy line and 60 ft for 5.2-ton charges with 600 ft of buoy line) was taken into consideration. Current conditions had very little effect on depth measurements. It is estimated that the 1-ton charge depths are accurate to ±10 ft and the 5.2-ton charge depths to ±20 ft. In every case, measurements are made to the top of the charge.

** Water depths are obtained from fathometer data and/or pressure wave travel-time computations with the method indicated by an 'a' (fathometer data) or a 'b' (travel-time computation).

*** Times, representing arrivals of pressure waves received by a marine geophone (see Material Inventory, Appendix B, for description) and recorded on a Visicorder, are converted to GMT and are accurate to ±0.1 sec.

Figure

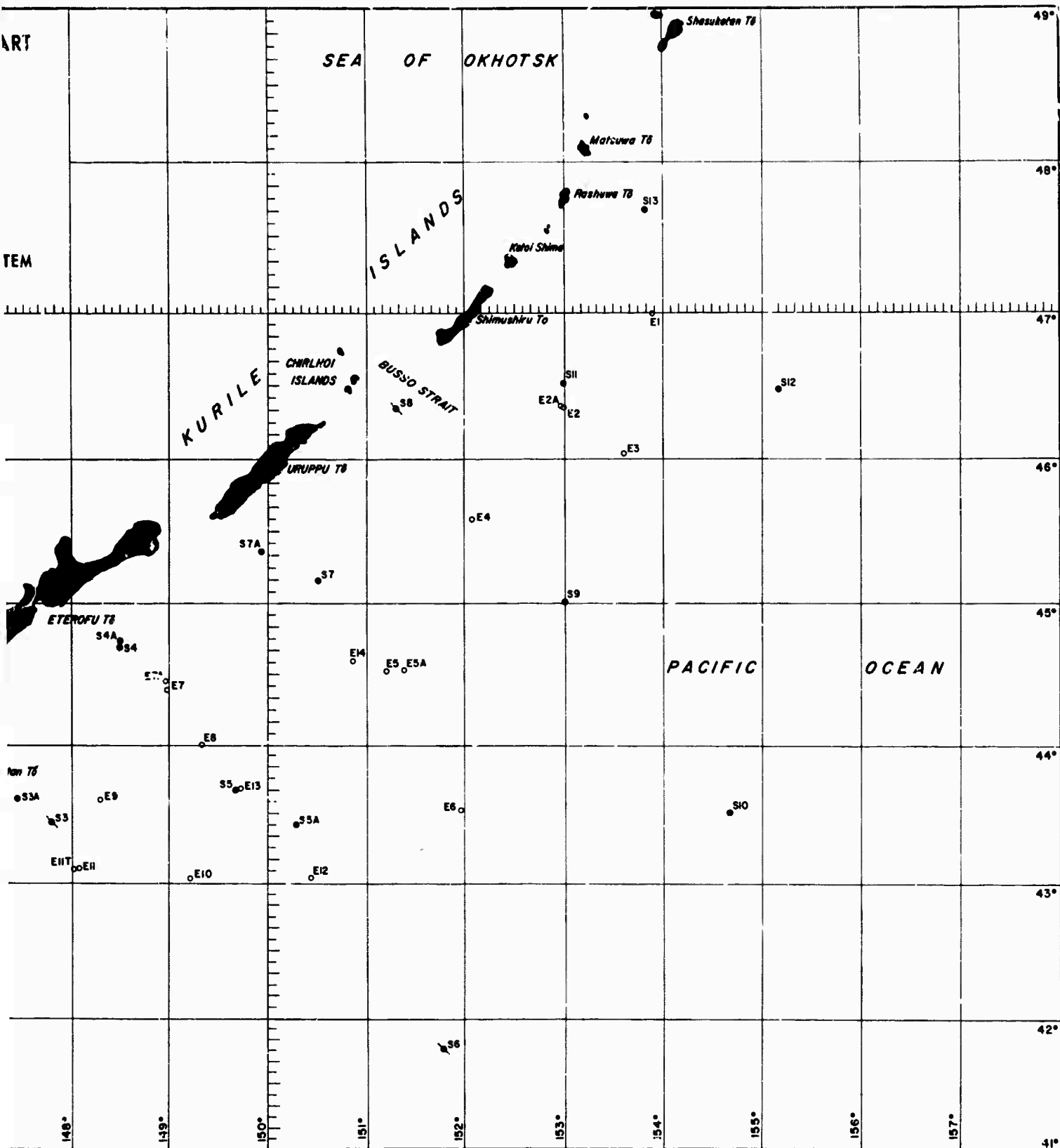


Figure 5. Event and System Chart

II-9/10

B.

BLASTER
CHANNEL

DETONATION SPIKE:
2249:03.0 GMT

TIME SPIKE:
2249:03.0 GMT

TIME
CHANNEL

FIRST BOTTOM REFLECTION:
2249:06.4 GMT

GEOPHONE
CHANNEL

INITIAL BLAST:
2249:03.6 GMT

2 SEC
TIME LAPSE

5.2 TON CHARGE @ 680 FT
WATER DEPTH: 1417 FM
LOCATION:
44°25.5'N 148°58'E
DECEMBER 3, 1966
POSITION E7A
Visicorder Recording, 5.2-Ton Charge Detonation



SECTION III

CRITIQUE

This program was completed 5 December 1966 without a misfire. The operational procedure gave good data results.

The ship's rigging contributed greatly to the program's success. An A-frame and crane combination is recommended for future operations.

A 2000-v blaster was not capable of firing charges when more than 1 mi of Type DSA-500-31246 firing line was used.

Rough weather conditions and the need to rely upon celestial navigation forced some delay in schedule and uncertainty in event locations. The vessel was stable enough that charges could be loaded in 15-ft seas as the ship moved between locations.



APPENDIX A
RELIABILITY DATA

BLANK PAGE



APPENDIX A

RELIABILITY DATA

Event timing reliability varies with Visicorder record quality and/or time-signal reception. Record quality classification (Table 1) is based upon both, with emphasis on time-signal interpretation. Figure A-1, showing several time traces and their interpretation, gives additional time-signal characteristics. Signal distortion may occur (Figure 6) due to noise, interference, etc.; however, reliable time interpretation is possible with detailed analysis.

Charge-depth reliability is indicated in Table 1 and discussed at the bottom of the table.

Water depths have been computed (Figure A-2) for each event where a geophone recording was available. Disagreements between these and fathometer data are due to ship's drift while the fathometer was off. Depth values in Table 1 have not been corrected for velocity gradient but are the most reliable when computed depths are used and are the best estimate with fathometer depths.

A 2- to 5-mi shotpoint-position accuracy was estimated after considering distance to the nearest celestial fix and weather conditions during fix, voyage traverse and at locations. Additional information on location reliability for events and systems can be found in Special Report No. 3 (Bathymetric Report, Kurile Experiment).

Geophone data on Visicorder recordings are as reliable as record quality. Resulting depth calculations are the most accurate for event locations.

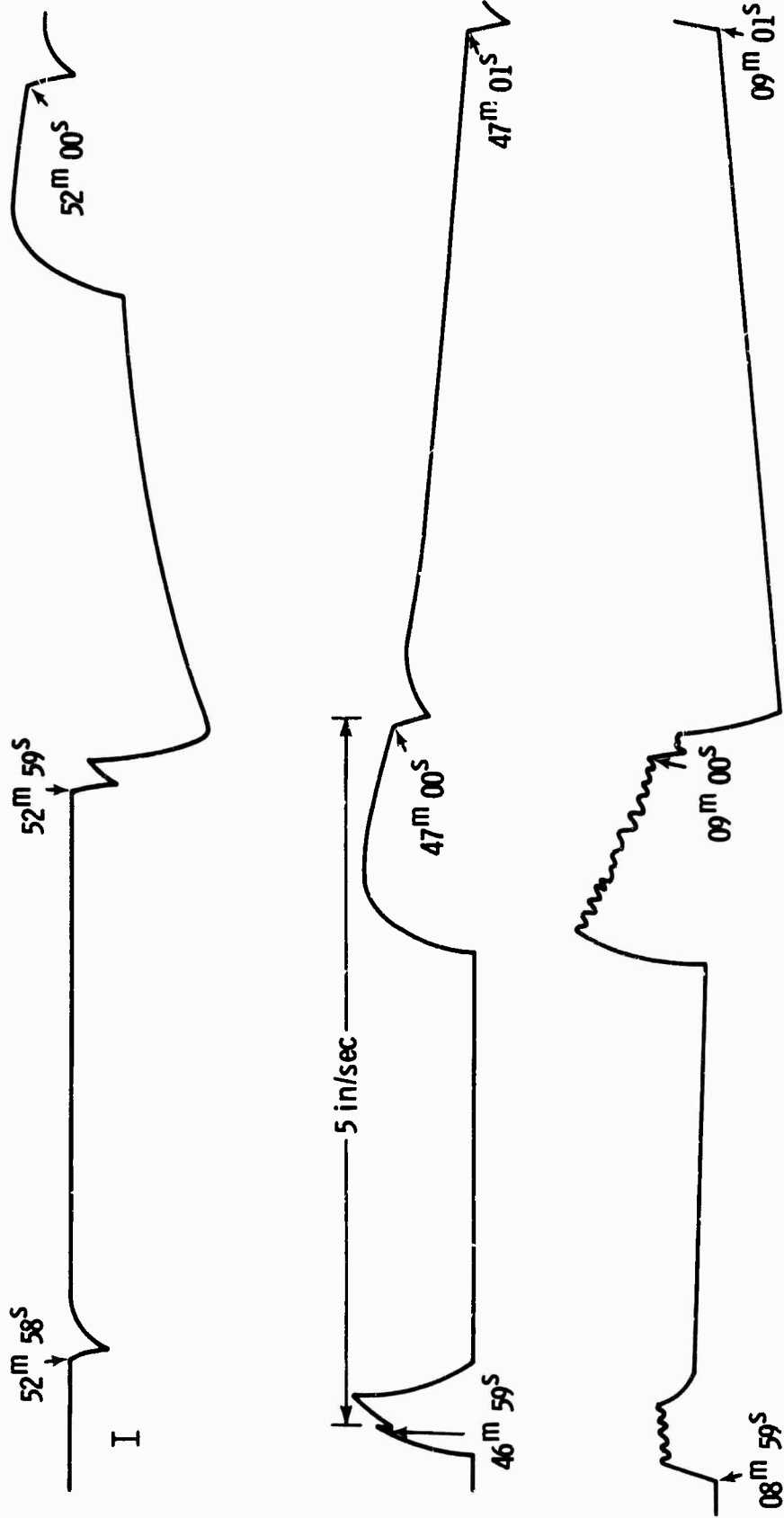
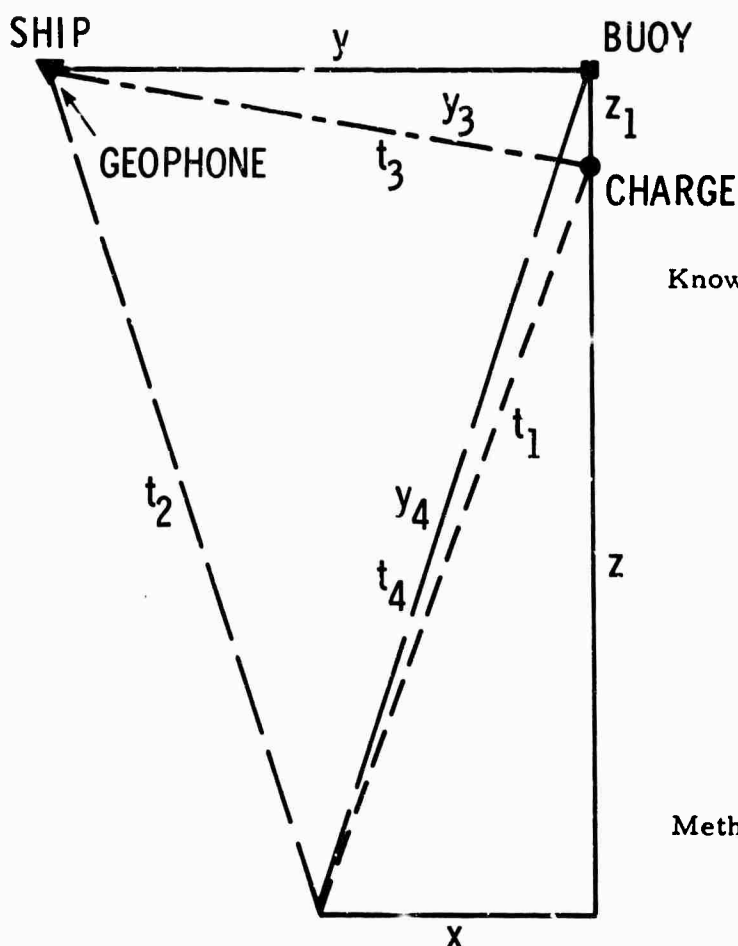


Figure A-1. Visicorder Recording of Three Time Signals Characteristic of Explosive Data


$$y_3 \approx v \cdot t_3$$
$$t_3 = \text{pressure wave travel time (sec)}$$
$$z_1 = \text{charge depth (ft)}$$
$$t_1 + t_2 = \text{total travel time of reflected energy (sec)}$$

$v \approx 4800$ fps (uncorrected for velocity gradient)

$$y \approx \sqrt{(y_3)^2 - (z_1)^2}$$

$$y/2 \approx x$$

$$t_4 \approx \frac{t_1 + t_2}{2} + \frac{z_1}{v}$$

$$t_4 \cdot v \approx y_4$$

$$z + z_1 \approx \sqrt{(y_4)^2 - x^2}$$

Note: Results from this method are approximate values. Depth accuracy was limited because velocity gradient was not considered, charge depth inaccuracy was ± 20 fm maximum and wave propagation angles were workable approximations.

Figure A-2. Travel-Time Computations



APPENDIX B
MATERIAL INVENTORY



APPENDIX B
MATERIAL INVENTORY

A. MATERIAL FOR EXPLOSIVES

1. 120,000-lb Composition B Class HE explosive: 2400—50 lb, 9-1/2-
x 9-1/2 x 9-1/2-in. cans
2. 60 primers: EL-637, 4x9 in., 7 lb
3. 100 WW boosters
4. 100 caps with 20-ft leads
5. Two insulated metal explosive boxes
6. Two wood-lined powder bins, 210 x 135 x 38 in.

B. PACKAGING MATERIAL

1. 10 metal tanks, 4 x 5 x 9-1/2 ft, 209-can capacity each
2. Six 650-ft rolls of 1-in. metal banding
3. One Signode coil box: DA/14, size 114
4. One Signode crimping tool: B-1435, size 1 $\frac{1}{4.035}$, PH 3136
5. 200 Signode metal clips: No. 114 OF
6. One Signode tensioner: 3A-114, PH 1146
7. One cutting tool
8. 2000 ft of 1/2-in. general-purpose nylon line
9. 75 lb of 1/4-in. manila rope
10. Eight 10-ft roller conveyors



C. FLOTATION MATERIAL

1. 10 polyurethane buoys, 30 x 36 in.
2. Two 8 x 4 x 4-ft wooden box buoys filled with styrofoam
3. 1800 ft of 1-1/2-in. nylon line (5-ton charge buoy line)
4. 1800 ft of 1-in. nylon line (1-ton charge buoy line)
5. 42 styrofoam blocks (line buoys), 10 x 20 x 9-ft

D. LUMBER

1. Lumber for one 1-ton charge:

<u>Qty</u>	<u>Dimensions</u> <u>(in.)</u>	<u>Use</u>
2	2 x 4 x 36	Lifting harness spacers
3	2 x 4 x 48	Pallet frame
2	1 x 6 x 38	Pallet cover
4	1 x 12 x 38	
2	2 x 6 x 84	Skids

2. Lumber for one 5-ton charge:

<u>Qty</u>	<u>Dimensions</u> <u>(in.)</u>	<u>Use</u>
4	1 x 12 x 96	Side spacers
1	1 x 12 x 108	Bottom board
1	2 x 6 x 108	Top board
4	2 x 6 x 84	Slide boards
2	1 x 6 x 36	Skids Slide-board spacers
8	1 x 2 x 6	Slide-board separators

For charge with reduced banding:

<u>Qty</u>	<u>Dimensions</u>	<u>Use</u>
2	1/2" x 19" x 8'	Plywood top covers



3. Nails

- a. 10 lb of Size 6 common nails
- b. 10 lb of Size 10 common nails

E. FIRING-LINE EQUIPMENT

- 1. Type 18 Tc WPR, Catalog No. 115-0559-01 heavy-duty, 2-conductor copper-coated steel with neoprene insulation, telephone wire. Firing capabilities: 2 mi at 2000 v
- 2. Type: Catalog No. 6145-243-8466 telephone cable, WD 1/TT on reel RL-159/u, copper-coated steel stranded 2-conductor wire with plastic insulation. Firing capabilities: 1 mi at 2000 v
- 3. Blasting cap safety plug, styrofoam ball with wood core. Hole for cap drilled in wood. Nail on each side used to secure temporary tag line and cap lead
- 4. Blaster, SIE (Southwestern Industrial Electronics) high-voltage blaster, SCD-2000 BA, Serial No. 4669E
- 5. Marine geophone, HPL Model S40P (1956); 30 in. x 2.5 in., 12 lb; frequency response, 0.03 v/in./sec @ 7 cps and 0.1 v/in./sec @ 15 cps; resonance frequency, 10 cps; output resistor, 500 ohms
- 6. WWV receiver, Specify Products Inc. Model No. WWVT 5-band receiver
- 7. Visicorder, Minneapolis Honeywell, Inc., Model No. 506, 12-channel paper recorder
- 8. 6-channel galvo-amplifier, Minneapolis Honeywell, Inc.

BLANK PAGE

347675

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Texas Instruments Incorporated Science Services Division P. O. Box 5621, Dallas, Texas 75222		2a. REPORT SECURITY CLASSIFICATION Unclassified	
		2b. GROUP —	
3. REPORT TITLE EXPLOSION PROGRAM - KURILE ISLANDS EXPERIMENT -SPECIAL REPORT NO. 2 - OCEAN-BOTTOM SEISMOGRAPH EXPERIMENTS			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Special			
5. AUTHOR(S) (Last name, first name, initial) Guidroz, Ralph; Howard, R. Fred; Frederic, John			
6. REPORT DATE 28 April 1967		7a. TOTAL NO. OF PAGES 22	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. F 33657-67-C-0105		8a. ORIGINATOR'S REPORT NUMBER(S) 9) Special report no. 2. 4) SR-2	
b. PROJECT NO. VELA-T/6708		8b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) —	
c.			
d.			
10. AVAILABILITY/LIMITATION NOTICES Distribution of this document is unlimited			
11. SUPPLEMENTARY NOTES ARPA Order No. 624 Program Code No. 6F10		12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Department of Defense The Pentagon Washington, D. C. 20301	
13. ABSTRACT This report details the procedures developed for the explosion program and gives the reliability of the calibration program. The explosive used was 120,000 lb of high-energy composition B packed in 50-lb cubical cans, which was shot in ten 5.2-ton, six 1-ton and one 1.5-ton packages. These charges were exploded in a network designed to provide optimum recording on the ocean-bottom instruments and minimum damage to marine life. The shots were restricted to the following conditions: daylight hours, 2 mi or more from any approaching vessel, a minimum of 13000 fm of water depth, and/or more than 100 km from land. The operational procedure gave good data results. The ship's rigging contributed greatly to the program's success. An A-frame and crane combination is recommended for future operations.			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Explosion Program Procedure Calibration Program Reliability A-Frame, Crane Combination Kurile Islands Experiment Ocean-Bottom Seismograph						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, sub-contractor, grantee, Department of Defense activity or other organization (corporate author) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive S200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (either by the originator or by the sponsor), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (paying for) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.